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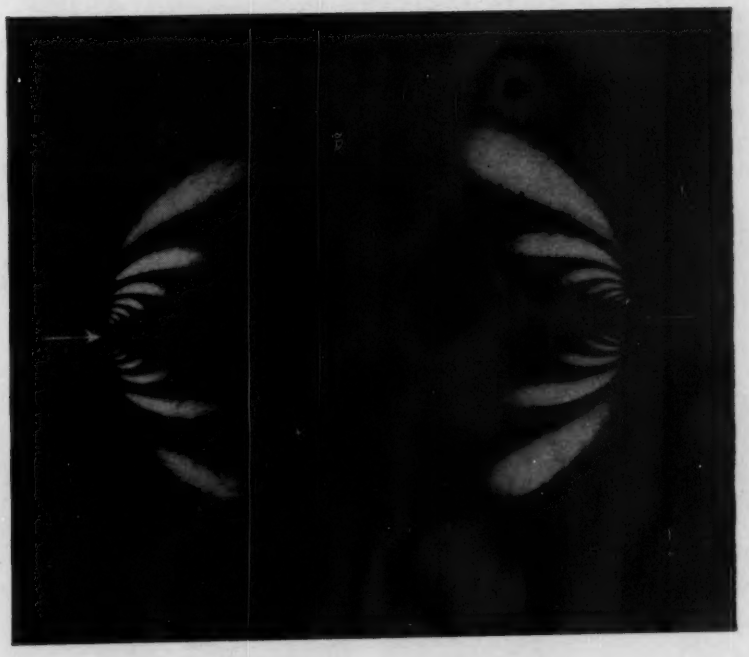
THE TECH ENGINEERING NEWS



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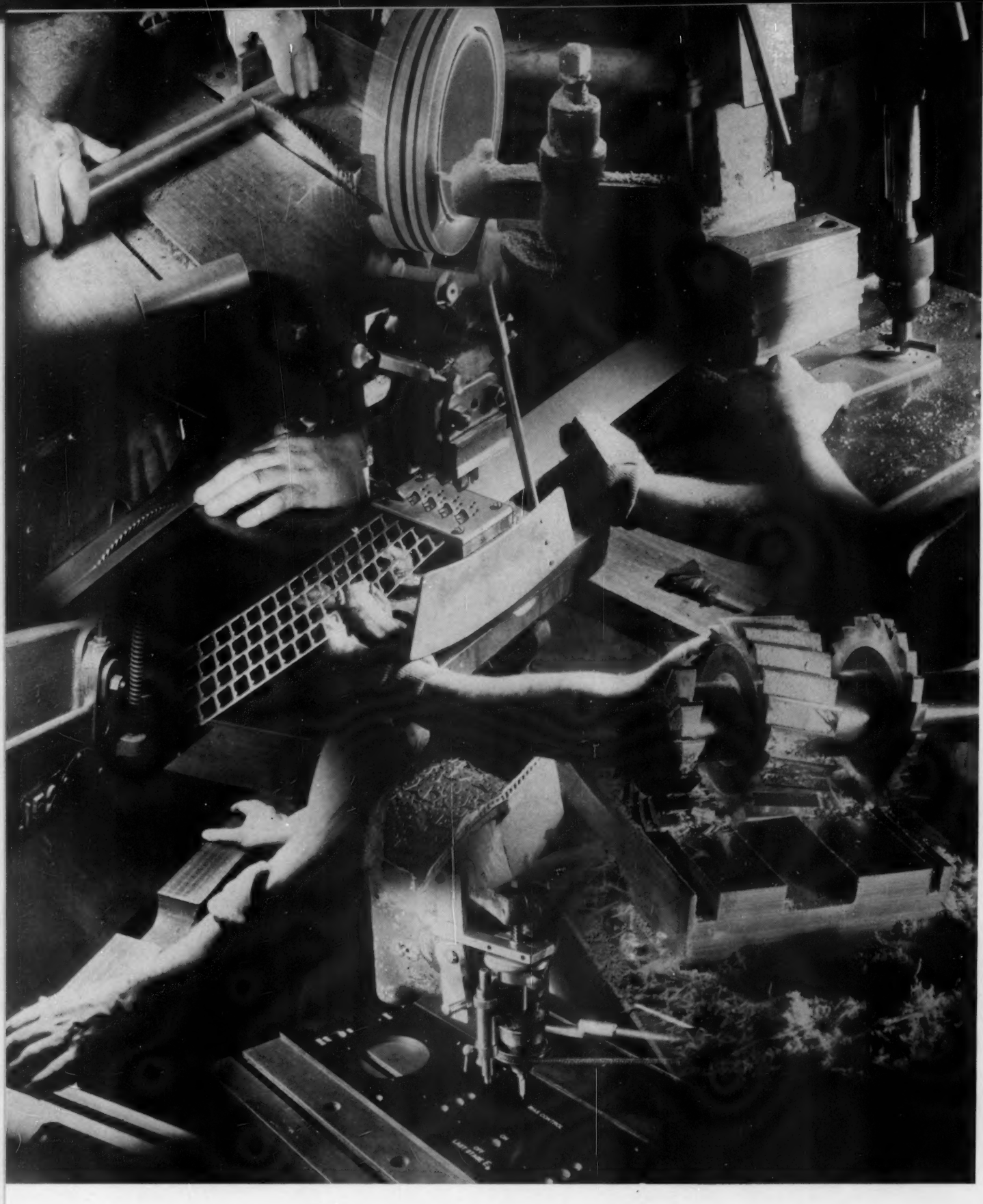


PROCESSING PLASTICS

Use of Physical Science In

CRIME DETECTION

Aids Federal Investigators

By J. EDGAR HOOVER
Director, Federal Bureau of Investigation

EVEN as various portions of the electromagnetic radiation spectrum were at first considered entirely separate entities, only to be later shown to be the same entity, differing in the single fundamental characteristic of wavelength, so have physics, chemistry, and other related sciences, formerly considered as entirely separate fields of endeavor, merged with each other and blended to such an extent that it is now often extremely difficult to say, "This subject, this experiment belongs to physics; this, to chemistry; and this, to biology". In proof of this, it is necessary only to cite the growth of such lines of study as biochemistry, physical chemistry, physiological optics, and others. Consequently it is correspondingly difficult to take the relatively new field of scientific crime detection and definitely state, "This contribution was made from physics, this from chemistry, and this from some other science".

In spite of these considerations, however, certain apparatus and certain techniques are still more or less closely associated with the parent sciences, although the use to which they are at present being put may be far from the particular need or line of thought which gave rise to them, and it is in this light that the following phases of the indicated branches of scientific crime detection are considered as having their origin in the field of physics.

The examination of questioned documents is one of the oldest of the police laboratory sciences and at the present time has grown to such proportions that it would require a relatively large volume for its comprehensive exposition. Consequently, only a very brief discussion is possible in an article of this nature, even when the subject is restricted as in the present case to those phases in which applied physics is involved.

Perhaps one of the most fundamental ways in which the science of physics has contributed to the examination of questioned documents may be found in the use by the document examiner of various measuring devices. For instance, an extortion letter submitted to the Technical Laboratory in the FBI for appropriate examination may undergo certain chemical treatments which will alter to a large degree the physical properties of the paper and writing materials employed by the extortionist. Therefore, in order that these physical properties may be available for comparison with similar characteristics of possible subsequent extortion letters or with the corresponding characteristics of stationary found in the possession of a suspect, it is necessary that measurements be taken and a permanent record made for reference purposes.

Thus, an accurate scale is used to determine the length and breadth of the letter paper to the hundredth of an inch, finely graduated micrometer calipers accurate to one-ten-thousandth of an inch are used to determine the paper's thickness, and a delicate balance indicates its weight. In some instances also, it may be desirable to make a record of the color of the paper or the ruled lines thereon; if so, several standard color charts are available for direct comparison, or a spectrophotometric curve may be taken, depending upon the circumstances surrounding the specific case and the degree of precision required. In a similar manner the color of the ink may be recorded. It is obvious, of course, that the application of these measuring devices is not limited to the examination of extortion letters, but is equally valuable in the examination of any document where a record of physical characteristics is desired.

In another phase of document examination, namely the study of disputed handwriting or typewriting, still other types of measuring instruments find application. For example, various styles of protractors are used to measure the angle of slant of handwriting or the angle from the vertical of a typewritten letter which is out of line. Other transparent scales measure lateral or vertical displacement, radii of curvature, proportion, and similar characteristics of the writing in question, characteristics which are vitally important to the expert conducting the examination.

A second but no less important branch of physics which has proved of immeasurable value in connection with the examination of questioned documents is to be found in the field of optics. Not only the visible region of the spectrum but the infra-red and ultra-violet as well, have found successful application to many of the problems daily encountered by the examiner. Out of the innumerable examples which might be mentioned, there are cited below only a few of the cases in which applied optics has furnished a most welcome answer to an otherwise difficult problem.

A recipient of several extortion letters, unable longer to endure the mental torture to which he was being subjected, notified the Federal Bureau of Investigation of the receipt of the letters. An investigation was promptly launched, which brought to light several facts pointing rather strongly to a certain young man as the writer of the anonymous letters; the suspect, however, vigorously denied any connection whatever with the letters in question. A subsequent search of the suspect's home revealed among other items of investigative value a writing pad containing paper similar to that on which the extortion letters had been written, and accordingly, this pad was immediately forwarded to the Bureau's Technical Laboratory at Washington, D. C., with the request that an attempt be made to determine whether the extortion letters had in fact been written on paper from this pad. Upon arrival in the Laboratory, the writing pad from the suspect's home was placed under a special light so designed as to cast a parallel beam of visible light across the paper at almost grazing incidence, a procedure which brought into extremely sharp relief all indentations and other irregularities in the surface of the paper. In this particular instance the parallel ray lamp revealed indentations which corresponded exactly with the writing appearing on the last extortion letter, although under normal lighting conditions, no irregularities whatever could be discerned on the surface of the pad. Thus, through the application of optical principles, incontrovertible evidence was made available that the extortion letters had in fact come from the pad in question.

In another case, an anonymous letter received for examination by the Bureau's Technical Laboratory was found to have been mailed in an envelope originally bearing a printed return address, which however the extortionist had obliterated by applying a heavy overlayer of ink. Here a knowledge of the action of the infra-red portion of the spectrum indicated to the examiner that although the overlayer of ink was completely opaque to visible light, infra-red radiation might be able to penetrate the covering and thus reveal the hidden

Illustrations on this page courtesy Scientific American

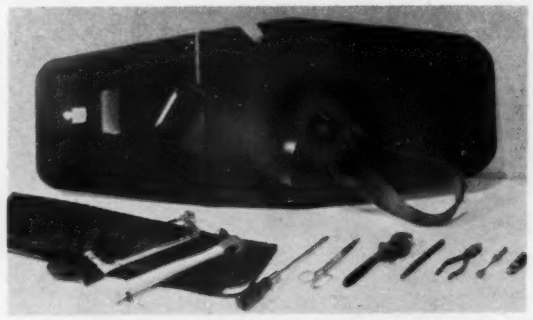
A collection of equipment for field offices of the Federal Bureau of Investigation, includes such items as tools, lights, binoculars, and of course hand cuffs.

return address. Accordingly, by the use of suitable optical filters and special photographic plates, a photograph was taken of the questioned area utilizing only the action of infra-red light on the plate and excluding all effects due to visible light. When developed, this plate showed the "obliterating" overlayer of ink as a very light smudge, through which the original printed return address stood out in clearly readable contrast. Thus, by properly applying a knowledge of the principles of selective optical absorption to the problem, the examiner was able quickly and accurately to determine the source of the stationery employed by the extortionist, an accomplishment which could have been attained only after the expenditure of considerable time and effort without the assistance of infra-red photography. Indeed, utilization of this ability of infra-red light to penetrate certain materials which are opaque to visible radiation has come to be one of the most reliable techniques at the present time for the determination of obliterated writing.

Light within the ultra-violet region on the other hand, is of value to the document examiner for an entirely different reason, namely the ability to cause certain types of material to fluoresce or give off light of a different color from that incident upon the material under examination. The exact color band re-emitted from the illuminated material is dependent upon the substances present and is more or less characteristic of them. Although fluorescent light is by no means limited to the visible region, it is in the visible region that this phenomenon finds its greatest application in connection with the study of documents, perhaps largely because of the relative ease with which visible fluorescent light is detected an interpreted as compared with methods necessary for the examination of invisible light. Accordingly, in order that the fluorescent light may not be masked by reflected light, it is necessary not only that the ultra-violet lamp be provided with a filter excluding visible radiation from the source, but also that the examination be carried out within a darkened enclosure.

In actual practice, ultra-violet light has been found particularly valuable for the detection of erasures on paper. Areas within which erasures have been made have their surfaces modified to such an extent that the difference in fluorescence is readily visible under the ultra-violet light, whereas frequently little or no effect is discernible in ordinary light. If the erasure happens to have been physical, that is, by means of a sharp instrument or an abrasive, examination under the ultra-violet light, while revealing the fact that an alteration has been made, frequently fails to disclose the original writing. In such a case, some other means must be taken to restore the erased writing. If however, the erasure has been carried out by means of chemicals, the ultra-violet light in addition to detecting the presence of an alteration, quite frequently will permit the original writing itself to be determined. The reason for this, of course, lies in the fact that the chemical eradicator does not actually remove the writing, but usually changes it into a colorless compound which retains its original position on the paper. Consequently, under the ultra-violet light, the fluorescence of this "colorless" compound enables the original writing to be read.

The detection of secret writing is another application in which the ultra-violet light has rendered most welcome assistance to the document examiner. Purportedly innocent correspondence between prisoners and outside friends has been found in several instances to reveal a dual message under the ultra-violet lamp, only one of the messages, however, being visible under normal lighting conditions.



Shield and kit of tools used by Special Agents in certain phases of their crime work.

So valuable in fact has the ultra-violet light proven itself, both from the standpoint of results obtained and in ease of operation, that examination under the ultra-violet lamp has become a routine procedure in the handling of many types of cases involving documentary evidence.

A second major phase of scientific crime detection work to which physics has made many valuable contributions lies in the analysis of physical evidence found at the scene of crime or otherwise pertinent to the investigation in progress, and in this connection, quite frequently such physical evidence gathered at the scene of crime is the only "eye" witness available. Thus, upon the proper analysis and interpretation of tiny fragments of steel may depend the solution of a horrible bombing, and upon the analysis of a few fibers left clinging to a window sill, the solution of a kidnaping or burglary; examples almost without end could be cited. Accordingly, it is readily seen that the importance of improvements in this field can hardly be over-estimated.

Of the many contributions made by various sciences to this work of analyzing evidence, none perhaps is of greater importance than the microscope. Hundreds of times each day it is called upon to work its magic in order that the law enforcement officer may know whether the wisp of hair found grasped in the hand of the murdered man is identical with samples taken from the head of a suspect; whether the blood stain found upon the floor of a suspect's home is indeed that of a chicken as claimed by the suspect, or is actually human blood of the same type as that of one of the murdered women whose mutilated bodies were discovered the day before in the river.

Fundamentally the result of a relatively simple application of optical principles, the microscope has become an indispensable part of the scientific crime detection laboratory, not only from the standpoint of handling current examinations but also from the standpoint of conducting valuable research.

In the petrographical microscope a further application of optical principles is found in the use of polarized light for the analysis of crystalline materials. By observing through an analyzer or second polarizing medium, the effect which tiny crystals under the microscope have upon the polarized light with which they are illuminated, the petrographer is able to determine, for instance, many of the minerals making up a sample of earth taken from the shoes of a suspect and thereby determine whether the suspect has recently walked in the vicinity where a certain crime is known to have been committed.

A more recent addition to the instruments at present employed in connection with scientific criminal investigation is found in the quartz spectrograph. Although this apparatus has long been of outstanding importance in physical and chemical laboratories throughout the world because of the many fundamental problems to which it may be applied in connection with those sciences, it is only lately that it has received any serious consideration in connection with scientific crime detection. The Federal Bureau of Investigation, keenly aware of the tremendous assistance already gained from scientific methods, has installed in its Technical Laboratory an instrument of this type with a view to ascertaining the extent to which this powerful tool may be used in police science work. Thus far, its principal applications have been found to lie in the qualitative elemental analysis of materials too small in quantity to yield readily to the usual chemical methods, and in the detection of traces of materials too small to be detected with certainty by the ordinary chemical tests. However, it is believed that as yet the surface has only been scratched in this line of research.

To cite an instance in which the spectrograph already has proved of value in connection with investigative work, an extortion letter received for examination demanded that the victim deposit a sum of money by the side of a certain rock which was to be identified by the presence of white paint on its surface. Investigation in the vicinity of the proposed payoff

Moulage reproduction of guns.

spot disclosed such a white painted rock; accordingly, a portion of this paint was scraped off and transmitted to the Technical Laboratory of the FBI, together with a sample of white paint found in the possession of a suspect, with the request that the Laboratory determine whether the two samples of paint were identical. A spectrographic analysis of the small fragments of paint removed from the rock indicated that this paint was of the zinc base type, with only traces of titanium present; a similar analysis of the suspected paint revealed that it was of the titanium base type and thus could could not be identical with the paint used by the extortionist. Because of the limited amount of paint which could be removed from the rock, a chemical analysis and comparison would have been extremely difficult, whereas with the aid of the spectrograph the task was performed quickly and accurately. In this and related types of identification problems, the spectrograph appears to hold considerable promise for the future.

Still another aid in analyzing physical evidence is that mentioned earlier in connection with document examination, namely the ultra-violet light. It was stated there that many materials when placed under a source of ultra-violet light from which the greater part of visible light has been excluded, fluoresce or glow with a light characteristic of the substance illuminated. Consequently, by comparing the fluorescent light from an unknown sample with the fluorescent light of known materials under the same circumstances, it is frequently possible to determine the nature of the unknown sample. In its more exact form, analysis by this method requires the spectrographic examination of the fluorescent light; however, visual inspection and mental evaluation of the fluorescent light are sufficient for many of the more common examinations required.

Thus in connection with rape cases, it is necessary that garments be examined for seminal stains, and inasmuch as such stains fluoresce brilliantly under ultra-violet light, the use of a light of this type offers a convenient and rapid means of examination. In this particular instance, the fluorescent light is utilized only to indicate those portions of garments to be subjected to other more specific tests because other materials are capable of producing stains whose fluorescence closely resembles that of semen and because specific tests are available which are less cumbersome than spectrographic analysis of fluorescent light.

Besides the above indicated equipment, there are many additional pieces of physical apparatus such as the refractometer, colorimeter, comparison microscope, photographic and photomicrographic apparatus, and others which daily are finding equally valuable application to the problems of evidence analysis, but which space will not permit to be discussed in detail.

This phase of scientific crime detection, as is more or less generally known, relates principally to the examination of bullets and shells recovered in connection with the investigation of a crime, with a view to determining whether they have been fired from a suspected gun. Of course, there are several other problems which properly fall within the scope of firearms identification; the majority of the work, however, is of the type indicated. In conducting such an examination, advantage is taken of the fact that every weapon leaves its own characteristic microscopic markings on both the bullets and shells fired in it. Consequently, the problem of determining whether a certain bullet was fired through the barrel of a questioned gun resolves itself into a determination of whether the microscopic markings on the questioned bullet are identical with the markings on a test bullet fired from the suspected gun.

In order to facilitate such a comparison it is essential not only that the minute characteristic markings be magnified in

Students of the Training School, Federal Bureau of Investigation, collect and record all the evidence found at the scene of hypothetical crime.

Illustrations on this page courtesy Scientific American

some degree, but also that means be available for accurately ascertaining when the markings on one bullet or shell coincide with those on another. The most obvious way to accomplish the latter requirement would, of course, be to cut the questioned and test bullets in such a manner that portions of each might be placed in juxtaposition and the identity of the markings thus directly observed.

Fortunately it is unnecessary to employ a method so destructive of evidence as this, for from the field of applied optics has come an instrument known as the comparison microscope which not only magnifies the bullet markings to almost any desired degree, but also optically "splits" the bullets and places opposite halves in proper juxtaposition without in any way multilating the bullets themselves. Thus upon looking into the eyepiece of such an instrument when focused upon two bullets from the same gun the characteristic markings of one bullet are seen to flow smoothly into those of the second, whereas if the bullets are not from the same gun, the lines of the first bullet will not correspond at all to those of the second. Here again, a difficult problem has been made easy by the proper application of physical principles.

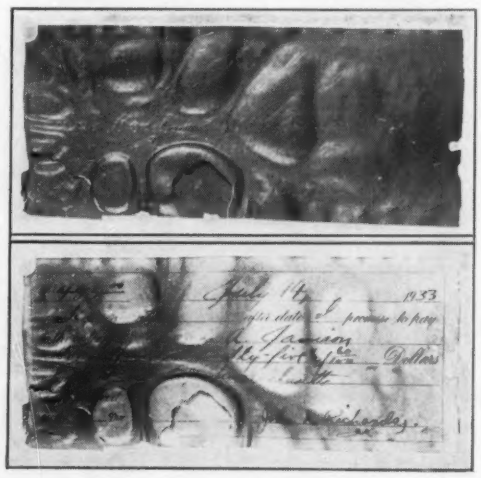
Scientific American

Equipment used by Special Agents for recording and preserving evidence at the scene of a crime. Accurate scale drawings are frequently made.

The laws of accelerated motion, also, are applied in the taking of test bullets by the firearms identification expert in that test bullets instead of being stopped abruptly are slowed down gradually to prevent the accumulation of sufficient force to deform them.

Undoubtedly the most valuable contribution of physics to the problem of explosives as encountered by law enforcement officers lies in the application of X-Ray equipment to the examination of suspected bombs. Although only occasionally encountered, the question of what to do with a package suspected of containing high explosives is a most serious one, and the ability of X-Rays to disclose the contents of a package without the necessity of opening or disturbing the package in any way is becoming more and more widely used as knowledge of its safety spreads.

In addition to the application of optics as embodied in the various types of magnifiers and projection equipment at present in use in connection with fingerprint examination and identification, an extremely interesting possibility of applying X-Rays to the fingerprinting of cadavers is worthy of mention. The method consists of rubbing the cadaver's fingertips with a relatively dense powder and then photographing through the fingers by means of X-Rays, thereby obtaining a picture of the characteristic ridge formation as outlined by the dense powder. Although as yet this method has not been used extensively, it appears to be capable of giving valuable assistance, particularly in those cases where, because of the withered character of the fingertips, it is impossible to obtain prints by any of the usual methods.



Popular Mechanics

Manner in which infra red photography reveals writings on charred materials.

Through the combined application of optical, electrical, and mechanical principles many devices have been developed for the purpose of detecting the presence of weapons or other metallic articles on the person of individuals coming within a predetermined area or enclosure. For example, a visitor to a prison may have concealed on his person a small weapon intended for one of the inmates. As he walks through a certain doorway, the presence of the metal weapon disturbs a balanced magnetic field which instantly causes a red light to flash and a warning siren to sound. Other similar devices depend upon balanced electrostatic fields or critically balanced oscillator circuits.

Many types of burglar alarms also utilize similar physical principles to throw a protecting "screen" about a predetermined area, the mere presence of an intruder within the protected area being sufficient to disturb the critical balance of the electrical circuits and their associated external fields. Other types of burglar alarms utilize visible, ultra-violet, or infra-red light to protect a given passageway or area, the operation in such instances depending upon the interruption of a beam of such light by the intruder. This interruption is registered by a photoelectric cell and relayed to any desired type of alarm signal. Obviously, devices of this type represent an important contribution to the rapidly increasing number of scientific aids against crime.

(*Continued on page 126*)

Modern Methods Make

PRE-FABRICATED HOUSES

Practical

By JOHN E. GREENHALGH, '39
Massachusetts Institute of Technology

THE past three years have seen the advent of an entirely new technique in the construction of the small house. Prefabrication, as this technique is popularly known, is the result of attempts to apply factory methods to dwelling construction.

This term, prefabrication, is somewhat of a misnomer for it implies that the product is completely finished at the factory. Obviously, it is not practical to ship a completely assembled house to the purchaser. For this reason the prefabricated house is not truly prefabricated, but rather a house built more simply by using parts which are factory made and assembled instead of manufactured by hand on the job. The modern factory built house must not, however, be confused with the typical portable house because portable houses are built of ready cut materials that so fit together that they may be readily taken apart. Prefabricated houses, on the other hand, are built with the intention of their being a permanent structure and the fact that some of them are removable is only incidental.

Prefabrication has many advantages over present methods of building, the major advantage being the lowered cost. Designers have found that but little saving can be made in the cost of materials so that any saving must be effected by shortening the construction time. The solution to this time saving problem is the use of machine made parts which may readily be united by simplified fastening devices.

Lowered cost is not the only advantage, however, for the manufactured house also offers improved design. Much effort is being spent in planning the houses so as to eliminate waste space and useless parts. The use of modern materials such as plastics and metals which offer increased strength, durability, and insulation is also featured in many designs. The improved insulation alone is a great advantage, for it results in a cooler house in hot weather and it makes possible the use of a small and economical heating plant in the cold weather.

Many types of prefabricated houses have been suggested by various designers, many of whom have built experimental structures and a few of whom have even sold their houses commercially. Many of these designs feature certain materials sueh as wood, concrete, or metal. Of those which feature wood we have the designs of the Forest Products Laboratory and the Haskelite Manufacturing Co.

The Forest Products Laboratory developed a house as a result of research into new methods of handling and using wood. Before building the house there were made and tested different designs of panels consisting of plywood over a light wooden frame. In designing the panels an effort was made to use the stressed covering principle of the aircraft designers. Tests proved the success of this effort and a design for the house was made.

The width chosen for the floor and roof panels was four feet because it was the width of commercially available plywood. The model house was planned with no spans greater than thirteen and one-half feet with the result that the depth of the structural members of the floor and roof panels was kept down to five and three-eighths inches; the extra strength and rigidity was given by the five-eighths inch thick top covering and a lower three-eighths inch thick. The wall panels were made of quarter inch plywood, four feet wide by eight feet long, on a frame one and three-eighths inches thick, the thickness being chosen simply because it corresponded to that of standard stock doors. These panels were fitted together with grooved wooden mullions and the joints were made weatherproof by filling the grooves of the mullions with a mastic before the panels were shoved into place. Special panels were made with door or window frames installed and all panels were insulated against heat and sound. The character of the wall panels made it necessary to hang the window sash outside the plane of the wall in order to produce a weatherproof job. This practice was novel but it solved the problem.

The floor and roof units are interesting. The roof is a flat sheet broken only by the chimney and central roof drain. This flat roof is curbed and railed so that it may be used as a sun deck. The floors, on the other hand, are of parquetry which is assembled on plywood sheets. The bathroom floor is an exception; it has a special surface of moulded wood plastic. Both the floor and roof sections are joined by wooden splines.

The plumbing and heating systems are standard, the latter being a one pipe furnace. The wiring, however, is done at the factory for each panel and the panels are connected by conduit when the house is erected.

Similar to the all wooden house is a house that is much the same with the exception that, instead of wooden mullions, metal I beams are used to join the panels. No direct load is placed on these I beams however; they merely stiffen the structure and enable it to support its own weight.

In both houses flexibility of design is stressed. The engineers say that the use of factory made parts should by no means result in identical houses for it is their intention that manufactured sections should be no more than economical substitutes for the conventional timbers, boards, and shingles.

Wood, however, is not the only material being considered for the new type of housing for concrete, too, is receiving much attention. Several distinct classes of concrete houses have been built.

One type is that employing concrete panels. This house utilizes special mosaic concrete panels made of colored quartz gravel, sand, and portland cement. These panels are cast in special moulds which are removed just before the final hardening of the cement in order that the surface may be washed with acid and wire brushed so as to expose the colored aggregates. When finished, the panels are two inches thick, nine feet high, and from four to ten feet wide. They are reinforced with steel mesh and the window frames are cast in during the moulding process. To assemble the house the panels are erected on a wood or metal frame and reinforced columns are cast behind them.

There are several designs of houses which incorporate similar ideas. One uses panels of ordinary concrete which are stuccoed after erection. Another introduces the use of grooved concrete studs similar in form to those of the wooden houses. In the latter, panels are finished in the mould.

A quite different use of concrete employs machine made slabs three feet long and one foot high. The slabs are erected in single or double rows with poured studs at frequent intervals. Each slab is reinforced along the long edge with a steel bar which is bent so as to key into slots above and below.

There is yet another kind of concrete house which calls for hollow walls formed by using collapsible metal forms. An entire story is cast at once by this method. The walls are

finished with an exterior coat of paint and the interior with plaster being applied directly to the concrete. This construction, however, costs about ten percent more than standard frame and stucco.

All these concrete houses appear to have floors and roofs of frame construction with the possible exception of a cast first floor. It is likewise noted that there is no definite trend toward either peaked or flat roof design.

A survey states,"Of the precast unit wall systems the type using units about 12 inches high by 36 inches long in conjunction with precast or cast-in-place studs appears most promising." The same survey states the opinion, however, that the hollow, cast in place wall represents the ultimate in the use of concrete in small dwelling construction.

The metal interests also look toward housing as a potential outlet for their product and several metal houses have been built. A few of them even have metal for the exterior walls; other simply have a metal frame and lath covered with concrete or stucco. An example of the metal sheathed structure has walls and roof made of 16 gauge steel. The steel is formed into narrow panels with flanged sides which lock together to form strong steel columns which serve as a framework. The joints are weatherproofed with a special caulking compound. A slightly different house has enameled metal sheathing for both interior and exterior walls, the space between being filled with glass wool. The manufacturer has been developing metal buildings since 1925 and has recently turned his attention to housing, his previous buildings having been mostly lunchrooms.

Not only steel but aluminum, copper, and stainless steel have been tried by different designers. Stainless steel costs too much at present but enameled iron shingles are thought to be quite practical.

Metal houses have also been built using the cellular type of construction. Cellular steel, which has been in use for subflooring for several years, is now being adapted to wall construction with apparent success.

Other designers, however, are content to use steel frames with metal lath or lattice as a foundation for concrete or stucco and several houses of this sort have been built.

The house which is perhaps the most logical of all, however, is the house in which the materials are secondary to the design rather than the object of it. Such a house has been developed under the trade name of "American Motohomes." More than forty of these houses have been sold and for this reason alone they would be worthy of special attention.

These houses are erected on concrete foundations to which steel beams are bolted. The beams are enclosed so as to form a chamber through which warm air can be circulated to keep the first floor dry and warm. The wall materials are attached to a sturdy steel frame. The exterior wall panels are made of a cement-asbestos compound which requires no painting and the joints are covered with an aluminum alloy trim. The interior walls are also made of mineral compound and they are covered with a washable material so that no joints are visible.

The floors, too, are different for they are made of a rich colored wood plastic which requires only waxing.

The roofs of all models are flat and have central drains. They are used as sun decks.

The most original feature of the houses, however, is the "Moto-Unit", a steel cabinet containing the electrical and mechanical equipment for the entire house. All the plumbing, heating, and air-conditioning equipment is contained in this cabinet which forms a core about which the house is built. One side of the unit provides for the kitchen and the other side for the bathroom. The heater contained in the unit is unusually small because of the fine insulation.

Much thought has been put into the designing of these houses and also into the formation of a marketing plan. The homes are sold with the price including the foundation with the piping extending one foot beyond the wall. This does not include the excavation cost which is slight for only a shallow space is excavated, the heater being on the ground floor. The houses are shipped by truck and are erected under the supervision of a company expert.

Although these homes are the most outstanding examples of metal-mineral construction there are several others using materials such as gypsum sheets and castings or various plastics and synthetic resins. Gypsum, however, requires careful waterproofing if it is to be used externally.

Nearly all prefabricated houses have features in common such as concrete foundations and little or no cellar. There is also a definite trend toward the use of a flat, centrally drained roof. Many designers are also attempting to install the electric wiring at the factory. Attempts to combine frame members and heating pipes are likewise not uncommon.

From an economic standpoint it must be said that prefabrication offers a method of providing cheaper yet better homes. Moreover, it offers steady work at lower but constant wages for the present system of intermittent work at higher wages which are necessary to compensate for the large amount of unpaid for time encountered by building labor. Factory production of housing units also has the advantage of mass purchasing power and more thoughtful design, for commercial designing leads to the economical use of proper materials which lowers the cost and, if carefully done, improves the product.

The charge of standardization has been effectively disproved by the flexibility of the designs thus far developed. Public opinion, unfortunately, is slow to accept this fact.

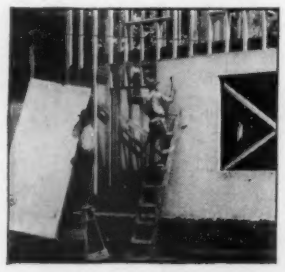
The designers have succeeded in many of their aims but as yet they have not brought about their promised reduction of cost. This weakness is only temporary as it results from the present small demand and the difficulty of gauging the future market. There is also a tendency to install excessive mechanical housekeeping equipment much of which is too expensive for the average family to run.

The style of architecture used in these houses is somewhat of a novelty in this country although it is common and widely favored in Europe. This novelty of appearance somewhat hinders their early acceptance but again, it is only temporary. Then, too, the public has the impression that prefabricated houses are of flimsy "summer cottage" construction and it must be admitted that the appearance of some types does give this impression, false though it is.

Another serious handicap to the development of this industry is the opposition of labor organizations of the building trade which are fighting hard against methods which will reduce job labor. Local building codes and regulations also oppose new methods.

The most serious handicap, however, is cost, for a sizeable reduction in cost would most likely cast the other objections into the background and produce a rapid expansion of the industry. With conditions as they are, progress will be slow but undoubtedly steady for prefabricated houses as they become more nearly perfected will be infinitely superior to the standard house of the present day.

Celotex Corp.



Institute Research On

VITAMINS

Leads to Water Soluble Derivatives

By PROF. NICHOLAS A. MILAS

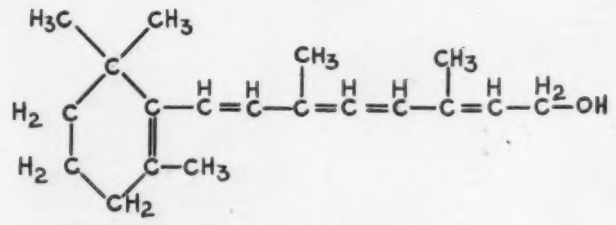
Assistant Professor of Organic Chemistry, Massachusetts Institute of Technology

DURING the past few years the scientific world has witnessed an unprecedented advance in the isolation and elucidation of the structure of many important biological substances which have been found to be vital and indispensable to health and well-being of the individual. Aided by the biologist and by the modern tools of research such as microanalytical methods, the spectroscope and the like, the organic chemist has been able to establish unequivocally the identity of many of the substances. Of these, the vitamins constitute a very important class. It would be impossible in the short space available to discuss adequately the chemistry of all known vitamins, so we shall confine our discussion to the chemistry of the vitamins to which our laboratory has made definite contributions. These include vitamin A or the anti-xerophthalmic vitamin and the antirachitic vitamins.

Vitamin A is entirely an animal product and its chief source is found in the fish liver oils which contain various concentrations depending upon the species. Cod liver oil, for example, contains about 0.04% while halibut liver oil contains as high as 10% of this vitamin. Although this vitamin is not found in plant tissue its precursors are of plant origin. Four of these, d–carotene, B–carotene, V–carotene and kryptoxanthin, have been isolated from various plant tissues. All are provitamins, that is, they break down in the liver under the influence of enzymes to form vitamin A; all are highly unsaturated colored substances, very sensitive to oxygen, and, with the exception of kryptoxanthin, contain only carbon and hydrogen. Structurally, like vitamin A, all contain the B–ionone nucleus and a system of conjugated double bonds both of which are considered necessary for vitamin A activity. No one has succeeded unequivocally in converting these, *in vitro*, to vitamin A. The reverse, however, has been accomplished recently in our laboratory by converting vitamin A into dihydro-carotene, a derivative of B–carotene.

Vitamin A has been shown to be a highly unsaturated alcohol of the type of geraniol. It is completely insoluble in water but soluble in most of the organic solvents which dissolve fats. It has never been crystallized and only recently we obtained it as a pale yellow solid from methyl alcohol at temperatures between -65 to $-75°$ C. Until recently the purest sample that has ever been obtained was that of Carr and Jewell, two English chemists, who obtained it by high vacuum distillation. Since this method of purification is known to cause cyclization of the vitamin thereby destroying its properties, this sample has not been considered absolutely pure although it has been referred to as the purest vitamin A sample and used as the basis for the calculation of the international vitamin A unit which is considered to be 1/2,560,000 g. of this. In other words, this sample contains 2,560,000 international vitamin A units per gram. Quite recently we succeeded, by numerous fractional filtrations at $-78°$ C. of methyl alcoholic solutions of this vitamin separated from the livers of the Albacore (Germo Germo), in obtaining a sample of vitamin A which has over 3,000,000 international units per gram. So far as it is known this is the purest vitamin A sample that has ever been obtained, but even this contains according to Professor Bunker, about 0.03% of vitamin D. Our process of purification is slow and laborious, yet we hope that the small amount of vitamin D present in our sample will soon be completely removed.

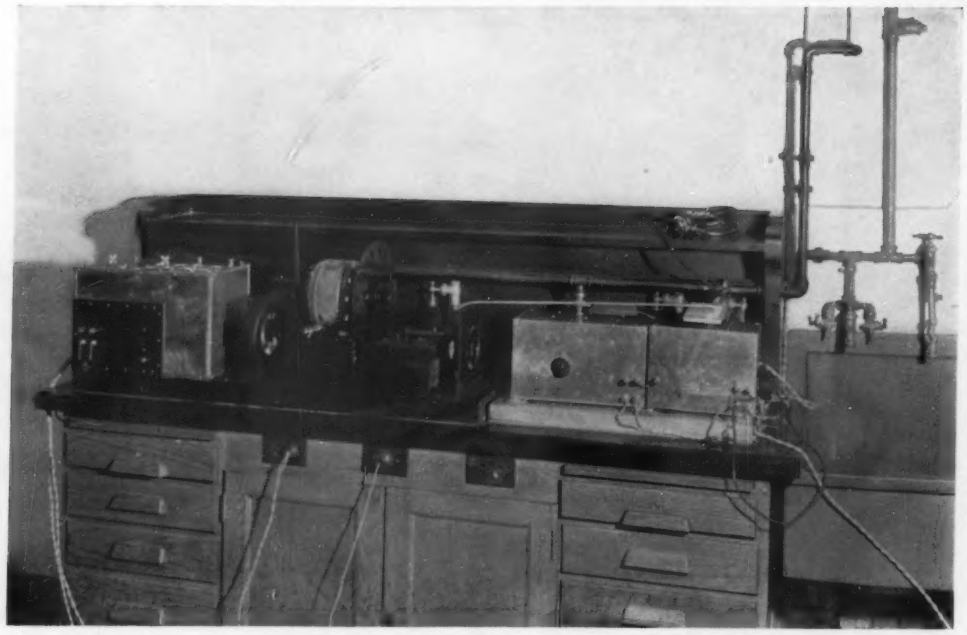
The structure of vitamin A which agrees best with its chemical properties is that represented by formula I and proposed by Karrer of Zurich and Heilbron of Liverpool. In natural oils it probably exists as the palmitic ester although this assumption has not been definitely established.



I—Vitamin A

This vitamin is usually administered in the form of oil solutions which are composed essentially of glycerides or some other edible oils. One can easily enumerate several objections to this mode of administration. For example, when this vitamin is administered to infants, the glycerides contained in the oil are not easily digestible. Even adults are unwilling to take this and other fat-soluble vitamins because of the objectionable taste of the oils in which they are dissolved. One of the objects of our work at the Institute has been to convert the fat-soluble vitamins into some water-soluble derivatives without destroying their vitamin properties. This is not easily accomplished since both vitamins A and D are highly sensitive to air, heat, and various chemical reagents. Notwithstanding these properties three different acid esters, the phthalic acid, the 3-nitro phthalic acid, and the ortho-sulfobenzoic acid esters, of the two vitamins have been prepared, the sodium salts of which are relatively soluble in water. It is felt that this work may be of some significance since the biological effect of these vitamins may be considerably accentuated in aqueous solutions.

In the development of our work in vitamin A we designed and constructed an instrument for the quantitative estimation of this vitamin. There are three general methods for the quantitative estimation of vitamin A: the biological method, the colorimetric method, based on a blue color produced by the interaction of antimony tricholoride in pure chloroform solution and finally the spectroscopic method which makes use of a prominant absorption band of the vitamin in the ultra-violet region. Of these the biological method is tedious and expensive, while the colorimetric method is inaccurate and not easily reproducible. To determine the concentration of vitamin A in a given sample, it is necessary to determine the relative intensity of a beam of monochromatic light in the region of 3280 Å, the maximum absorption of the vitamin, before and after it has passed through the solution containing this vitamin.



The new Photoelectric Photovitometer.

In the case of our instrument this is accomplished in a little different way. Monochromatic light in the region of 3280 A° is split into two beams, one passing through the solution and the other through the solvent. The intensity of the two beams is then compared photoelectrically. To make this comparison photoelectrically the two beams were converged on a sodium photoelectric cell and allowed to fall on this photocell alternately by means of a flicker disc containing 16 apertures at equal distance from one another. Since the disc rotates at constant speed of 1800 r.p.m., the light passes through each aperture 480 times per second. When light falls on the photocell at the rate of 480 times per second, it produces a photoelectric current the frequency of which is 480 cycles per second. An amplifier was then designed for us by Professor Fay of our Electrical Engineering Department and tuned for this frequency and no other frequency. When the two light beams are exactly of equal intensity, the first harmonic is absent from the resulting photoelectric wave and one hears a minimum sound over the ear phones, but as the two beams become unequal in intensity the first harmonic appears and can easily be distinguished by a trained ear. These effects can be reproduced more accurately by the oscillograph.

Naturally, the two beams are unequal in intensity when one passes through a solution containing the vitamin and the other through the solvent. The light beam that passes through the solvent is obstructed by means of a shutter until the two beams are of equal intensity as analyzed by the oscillograph. The arm of this shutter is constructed in such a way that it records directly on a logarithmic scale the extinction coefficient of the vitamin solution. From this the concentration of the vitamin can be calculated easily.

The results obtained by this instrument compare very favorably with those obtained by the spectrophotometer and are much more accurate than the Hilger vitameter. Table I shows some of the results obtained with the U.S.P. Reference Cod Liver Oil.

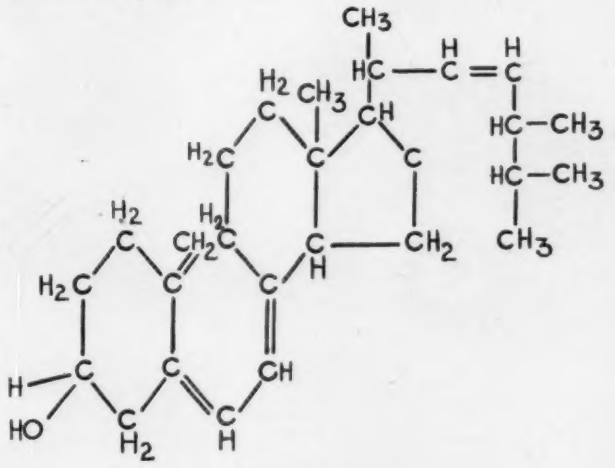
TABLE I
COMPARISON OF POTENCIES OF THE U.S.P. REFERENCE COD LIVER OIL

			E	*1% E 1 cm*		*Vitamin A in U.S.P.*	*Potency Units*
	% Conc.	*uncorr.*	*Corr.*	*uncorr.*	*Corr.*	*Uncorr.*	*Corr.*
Hilger	0.4076	0.81	0.68	1.99	1.67	3184	2672
Vitameter	0.4750*	0.77	—	1.62	—	2592	—
	0.5056	0.85		1.68		2690	
Spectro	0.3618	0.60		1.66		2660	
Photometer	0.2022	0.35		1.73		2770	
				Mean	=	2710	
	0.5056	0.86		1.70		2720	
Photo-electric	0.3618	0.60		1.66		2660	
Photo-vitameter	0.2022	0.37		1.83		2930	
				Mean	=	2770	
Biological value						3000	

* Reported by Mr. Francis Tripp of the E. L. Patch Co.

One of the antirachitic vitamins has always been found associated in fish liver oils with vitamin A. For several years this vitamin has been thought to be identical with that produced by the irradiation of ergosterol, a sterol occurring in plants. Recent investigations in this country and abroad revealed the fact that the artificially produced vitamin is not only different chemically from the naturally occurring vitamin but also biologically. We began working in this field some years ago in co-operation with our Department of Biology when we developed a new process for the production of the artificial vitamin from ergosterol by means of the high frequency oscillator.

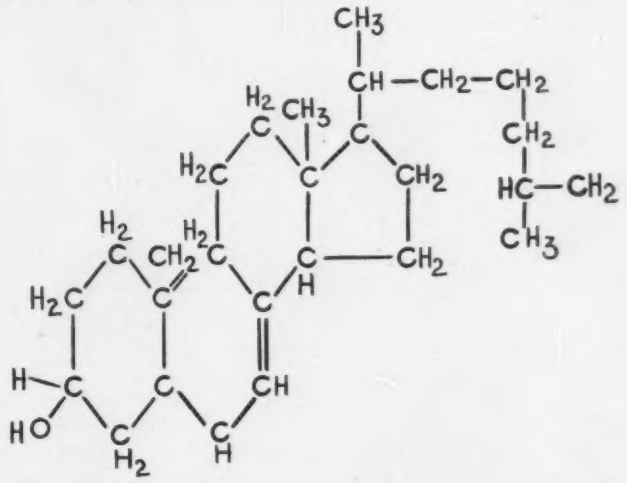
Although the photochemical conversion of ergosterol to a vitamin D or calciferol has been known for almost ten years, the chemical structure of this vitamin has been established only during the past year. Formula II shows the new structure of this vitamin



II—Calciferol.

recently proposed by Windaus and adopted by many other investigators in this field. This artificial vitamin is extremely powerful and an amount as small as 0.000000025 g. is sufficient to cure an albino rat from rickets. It is used commercially to fortify fish liver oils that are low in vitamin D content. The production of this vitamin has been the subject of several important patents some of which are owned by the University of Wisconsin. During the depression when funds were not available from other sources some of the income from these patents helped the University to keep up with its high standards of research.

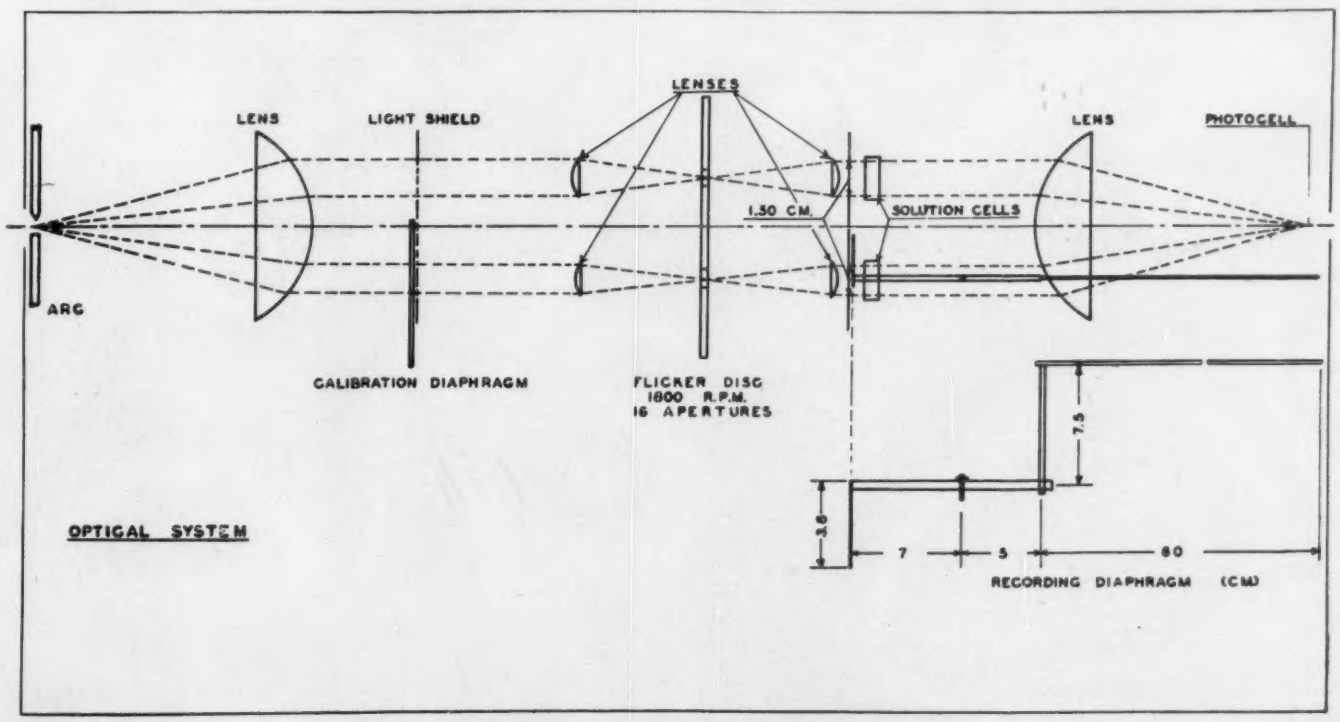
A second vitamin D has been produced recently by the irradiation of 7-dehydrocholesterol, a sterol artificially produced from cholesterol. The structure of this new antirachitic vitamin is represented by formula III. It may be seen that it differs from calciferol by a methyl group and a double bond. It has been found to be about two-thirds as potent as calciferol, but resembles more closely the natural vitami than does calciferol. In fact, recent investigations indicate that it may be identical with the antirachitic vitamin isolated from tuna fish liver oil.



III—New Vitamin from 7-Dehydrocholesterol.

The liver oil of the albacore which has been referred to previously is very rich in vitamin D as well as in vitamin A. When we began investigating the chemistry of the vitamins isolated from this fish liver oil, we decided to work out a process for the separation of these two vitamins in their pure state. This has been accomplished and our results so far indicate that the natural vitamin is different from that produced by the irradiation of ergosterol. These results and those of other investigators seem to indicate that vitamin D or the antirachitic factor exists in many forms and it would probably take several years before all of them have been isolated and their constitution definitely established.

In addition to vitamins A and D, fish liver oils contain vitamin E, the anti-sterility vitamin. Professor Evans and his colleagues of the University of California have been responsible for the discovery of this vitamin. Chemically this vitamin is related to sterols although its exact structure is not definitely known. Wheat germ oil is a rich source of this vitamin and quite recently Professor Evans isolated from this source an alcohol which he believes to be nearly pure vitamin E.



Precision Cameras Make

MINIATURE PHOTOGRAPHY

A Serious Hobby

By JOSEPH J. DONOVAN, '39
Massachusetts Institute of Technology

NO discussion of miniature photography would be complete without a preliminary sketch of the history of photography. Photography had its inception in the *camera-obscura* of the Renaissance. The *camera-obscura* was a device used by landscape painters to reduce the size of a view to the approximate size of the canvas on which they were working. From this reduction they were able to gain some idea of the size of objects and their proportions on the canvas. The principle used is the same as that of the pin-hole camera—a piece of ground glass was placed at one end of a light-tight box and a small hole pierced at the other end. When the light rays from the object passed through the pin-hole they focused upon the ground glass and produced a reversed image of the object, much reduced in scale.

Photography really started with the observations of Scheele on the darkening of silver chloride on exposure to light. These observations, made in the early part of the eighteenth century, were not followed up because Scheele could not find any means of preserving the "shadow-pictures" of objects, which he made by exposing paper coated with silver chloride to the light and coering a portion of it with an opaque object. The silver chloride darkened where it was exposed to the light and remained unchanged where covered by the object. A number of other men made similar observations, but it remained for Darguerre to discover, quite by accident, that the sensitized silver plates which he was experimenting with could be "developed" by exposing them to mercury vapor, and could be "fixed" or made permanent by bathing them in a saturated solution of common salt.

Developing is the process of bringing out the latent or invisible image impressed upon a photographic plate by a momentary exposure to a reflecting body. An interesting story is connected with the discovery of this process. It seems that Darguerre placed an exposed plate in the cabinet in which he kept his chemicals; after it had been there a day he took it out, intending to expose it still further on the same scene. He was greatly surprised to find a perfect image of the scene to which he had exposed the plate, since he had given it only one-half the exposure which was normally required. Darguerre tried this again, first removing all the stoppered bottles from the shelves; after he removed a dish of mercury he found that the atmosphere of the cabinet had no effect on his plates. He then removed everything but the mercury and left an exposed plate in the cabinet. The next day he found that it was completely developed.

The process of "fixing" receives its name from the fact that it makes permanent the image on the plate. It consists in removing the unreduced silver salt from the plate and so preventing the entire plate from turning dark on being exposed to the light. The removal of the silver salt is accomplished by the formation of a soluble complex salt which is then washed away.

It was soon found that the solid silver plates, coated with a thin layer of silver iodide or bromide, which had been used by Darguerre, could be replaced with glass plates on which the silver salts were deposited in the form of a suspension in egg albumin. As these plates had to be made immediately before they were required, and used while still wet, they were called "wet plates". When collodion came into use as a base for the emulsion it was possible to prepare dry plates—plates that could be prepared at home, dried, and used while dry. The development of the gelatin emulsion made possible the commercial preparation of photographic plates in large quantities. The first of these were rather insensitive to light. Although they were much more sensitive than the collodion plates, however, they were soon improved until they were so sensitive to light that an exposure of 1/1000 second in bright sun-light would give an image on development.

Cameras progressed along the same lines as the sensitive material. The first Darguerrotypes were made with a pin-hole camera; the wet-process pictures were taken with a camera containing a simple lens, and the succeeding developments in plates were kept pace with by developments in the optical equipment of the camera. The camera, however, remained as bulky and heavy as it had been in the early days of photography. The plate cameras could not be made less bulky until the development of light-weight alloys.

The developement of flexible celluloid film by George Eastman in the 1890's was responsible for a great change in the type and size of cameras. The first camera to use roll-film was a box camera taking a picture about two inches square. The development of strip film and sensitive emulsions began the present era of hand-cameras.

Without the invention of strip film Thomas A. Edison could not have developed the motion-picture camera or "kinoscope". Our modern motion pictures would be impossible to make or show without the ribbon of celluloid which Edison utilized in developing another man's idea into a working machine.

Miniature photography is really an outgrowth of motion picture photography. The first modern "miniature" camera, made by E. Leitz, Inc., was designed to use motion-picture film. Motion picture film was chosen as the medium for this camera because there were more types of film available for the camera than would have been available in roll-films. The use

Illustrations on this page courtesy Camera Craft

of motion-picture film also allowed the designers to make the capacity of the camera great enough so that it would hold 36 negatives without undue bulk.

There is another type of miniature camera which deserves mention—the twin lens reflex camera. These cameras use ordinary roll-film and work on the same principle as the standard reflex, with the difference that they have separate finder and taking lenses.

Some of these cameras have an artillery type range-finder situated on top of the camera and so connected with the lens that as the lens is turned the range-finder gives a double image until the object being focused upon is in exact focus. A battle rages whenever owners of the two types of this range-finder meet over the relative merits of the long-base range-finder and that with a short-base.

The types of film available for these cameras are legion: there are fine-grain orthochromatic films, fine-grain panchromatic films, and super-sensitive films of both types. The orthochromatic films are films which are over-sensitive to blue and relatively insenitive to red light; panchromatic film is over-sensitive to both red and blue light. The super-sensitive films are for work which requires extremely short exposures such as sporting scenes, candid photography, and stage pictures.

Illustrations on this page courtesy Camera Craft

A discussion of miniature cameras and miniature photography would be incomplete without an extensive treatment of the attachments and accessories available for these cameras. The manufacturers have striven for years to outdo one-another in this respect. Attachments are available which make it possible to take pictures of the pages of a book reduced about seven diameters, develop them, print them on positive film, and put them into a special lantern which projects the page onto a ground glass screen two or three times the size of the original. The Carnegie Institution now gives its research fellows in Europe complete outfits of this nature so that they can take pictures of the books owned by libraries and study them at home with greater ease than they could have in the library.

Many times lately pictures of stamps have been shown. These pictures were enlargements of the actual full-size pictures taken of the stamp. The use of copying attachments makes possible the taking of pictures of this type and of many others of a similar nature. The availability of special attachments for coupling microscopes to the miniature camera makes it an ideal tool for the scientist. Many of the photomicrographs which are taken today are taken with the miniature camera and this accessory. The use of the miniature camera in this field has made possible the taking of pictures of the life processes of the lower forms of life and the study of these pictures has led to a clearer understanding of the life processes in the human being.

The explorer and naturalist finds himself relieved of the necessity of carrying more than one or two kinds of film when he makes one of these miniature cameras his still picture equipment. He is then able to buy one or two kinds of motion picture film and save both space and money for other things. In addition he has available extreme long-focus lenses which allow him to take still photographs of shy subjects from a long distance, and have an image as large as or larger than he would have been able to get with the older types of camera. There is a lens made which gives the effect of viewing an object through a ten power telescope.

The small size and light weight of the miniature camera have made it a favorite with newspaper photographers because they can use it in places where an ordinary camera could not be used. This is especially true in court where cameras are often-times banned; of course the photographer must take pains not to get caught taking pictures or he will be jailed for contempt of court. With the aid of right-angle finders and other similar attachments the news-photographer can obtain pictures of celebrities who object to being photographed, without their being aware that he is even looking at them. The dramatic critic can also use the miniature camera with its fast lens equipment and super sensitive film to obtain pictures of the play which he is reviewing.

The stage pictures taken by people who make a business of entering pictures in salons are often very effective and beautiful. They are able to take snap-shots of the play as it is being acted without the use of any other light than the stage lights, and without annoying the people near them. This quality of the miniature camera makes possible its use in *candid photography*—that is the photographing of people in various places and positions without their being aware of it.

The miniature camera has been steadily increasing in popularity, and with this increase have come many improvements and refinements in design, until now many of our outstanding commercial photographers are deserting their cumbersome eleven by fourteen inch cameras for the little, convenient *minie*.

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EDITORIALS

MISGUIDED SCIENCE

COLONEL Lindbergh this last summer in Germany delivered a significant speech, calling attention to the enormously destructive war machines which are rapidly coming into being. The well known aviator warned the nations, without beating around the bush, that aviation is being exploited to the present advantage of the militarists, and for the future destruction of men and civilization. Aviation is a desirable thing when it is used for transportation purposes, but when thousands of pursuit ships and fighters lie idle in government hangars waiting for action, aviation becomes a menace. The destroying power of a modern bomber is greater than a battleship. The damage which could be inflicted on a city by a swarm of them is terrible to imagine. Granting that an air force is needed, investments in planes of war should be limited to those necessary for protection. To plan for the complete destruction and practical extinction of a future enemy is not in keeping with the modern ideas of humanity.

In the same way other scientific discoveries might be led astray by exuberant militarists. The work of a scientist is usually freely given to his government, but if it is misused he might justifiably stop future contributions. More often though the decision rests with the government,who encourages certain war supply industries with subsidies. Scientists, as a whole, should note where heavy investments are made in destructive implements, with a view to withdrawing their support from such enterprises. If their inventions get out of hand in a battle between nations, the fundamental responsibility for the gruesome damage they inflict rests on the inventors. Of equal importance is the fact that science may become entirely a tool of the government. Investigations and research might be supervised and regulated much as education is controlled in some nationalistic countries. These hindrances not only would be unbearable to real scientists but would stifle progress.

To protect themselves from these two challenges is the problem of all technicians and experimentalists, and looking at it crudely, it is to the scientists' advantage to see that the world's peoples do not suffer through the advancement of science. An armament race must not develop and prudent and concerted action by the scientists and technicians can do much to prevent it. Scientific and human progress must not bow down to the selfish whims of militarists.

APOLOGY

WE regret that in the June issue we failed to give credit to the Corning Glass Works for the illustration which was used on the editorial page.

PACIFISTS AND PACIFIMANIACS

WITH black clouds of war hanging menacingly over central Europe and the Far East and in these days of saber-rattling dictators, one is likely to hear a great deal about armament and disarmament. Those who urge almost complete disarmament go upon the false assumption that armaments are the cause of war whereas actually they are the product of war. Abolish war and armaments will be abolished, but the abolishment of armaments does not necessarily mean that war will be abolished. True pacifists strive to maintain universal peace by providing sufficient defensive security. Only the pacifimaniac seeks to preserve peace by complete disarmament. In a world of force it is absolutely impossible for any nation to disarm. If all nations disarmed simultaneously, it would mean that backward nations, by mere force of numbers would overrun the great nations who are the leading powers of civilization. Radical pacifists have dwelt on the immediate causes of war, on causes which were, in fact, selfish and foolish, but they have failed to consider the fact that the human mind, in times of stress, is incapable of determining accurately and invariably that which is right and that which is wrong, that which is true and that which is not true, that which is best and that which is not best.

To quote from *Inevitable War*, "We can and should prepare against defeat in war, and we can and should do it without delay, in a manner that will give security without menace to others, without militarism, and well within our financial means." A program that threatens no one, but guards our birthright is true pacifism.

NEW HOPE FOR STEAM

RECENTLY announced as having been contracted for by the Union Pacific Railroad, a steam turbine locomotive of revolutionary design is now being constructed. This new type of locomotive is being built by the General Electric Company and is scheduled to be delivered early in 1937. Essentially the same type power system as the ones on the large ocean liners is engaged in the design. Steam is employed to turn the generators which supply power to the driving motors. This system is also similar to that of the oil-electric type of locomotive in which the generators for the driving motors are turned by a Diesel motor.

The new locomotive will be lighter than a correspondingly powerful Diesel locomotive and will be capable of pulling a 1,000 ton train at 110 miles an hour. According to its proponents the steam turbine locomotive will offer efficient operation at lower costs than the conventional type locomotives and will lend itself to easy maintenance. When it is completed the new iron horse will undergo a series of exhaustive tests before it is placed in service. The ultimate effect of this type of construction on future design in locomotives will be apparent after these tests.

This new type locomotive will perhaps fit in with the comeback already being staged by the steam locomotive builders. Applying the same stream-line effects with which the Diesel manufacturers captured the public's eye, locomotive builders are holding and bringing back a majority of the major roads to steam with their new "steam engines". Many of the new "super-trains" such as the Chicago, Milwaukee, St. Paul & Pacific "Hiawatha", New York Central "Mercury", and Baltimore & Ohio "Royal Blue", are steam drawn stream-liners. Engineers of the roads still maintain that a steam train is the "fastest thing on wheels".

HARVARD TERCENTENARY

THE three hundredth anniversary of our friendly rival in the field of higher education is an achievement which one can not help but admire. Their prestige among the liberal arts colleges of the world is undeniable.

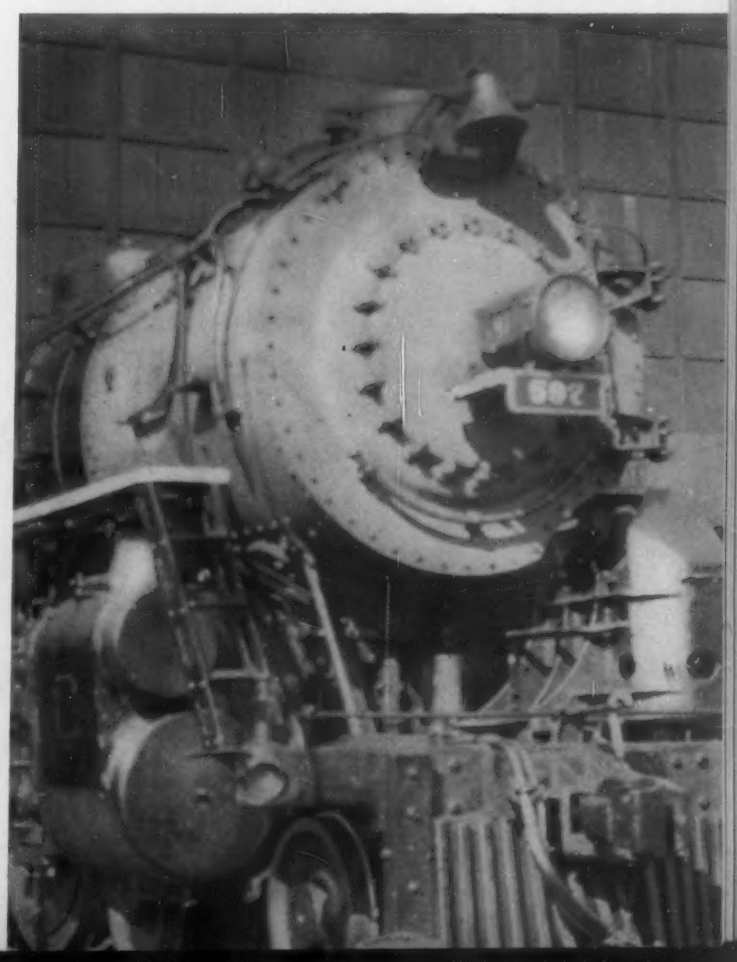
The magnitude of their celebration dwarfs our annual Open House, but in it one perceives a similarity of purpose and design. The immediate aim is to recruit students to maintain that great university, but underneath this is the desire to prepare the men who must be ready to step into responsible positions in the future. The superior training of these men is going to place them in government, business, and politics; fields on which the welfare of higher educational institutions depends considerably.

Now it is apparent that colleges are going to need all the favorable actions and propaganda that they can elicit from the hardboiled politicians of the world. Witness what has occurred in Germany since 1933. Learned professors have been dismissed, supposedly for racial reasons, but more often than once these men have been free thinkers with liberal ideas. Nationalistic Japan has also banned from its colleges subjects which are conducive to free thinking. Right in our own country we find certain groups taking steps to stifle individual thinking. They are the people who would force the Teachers' Oath Law upon us.

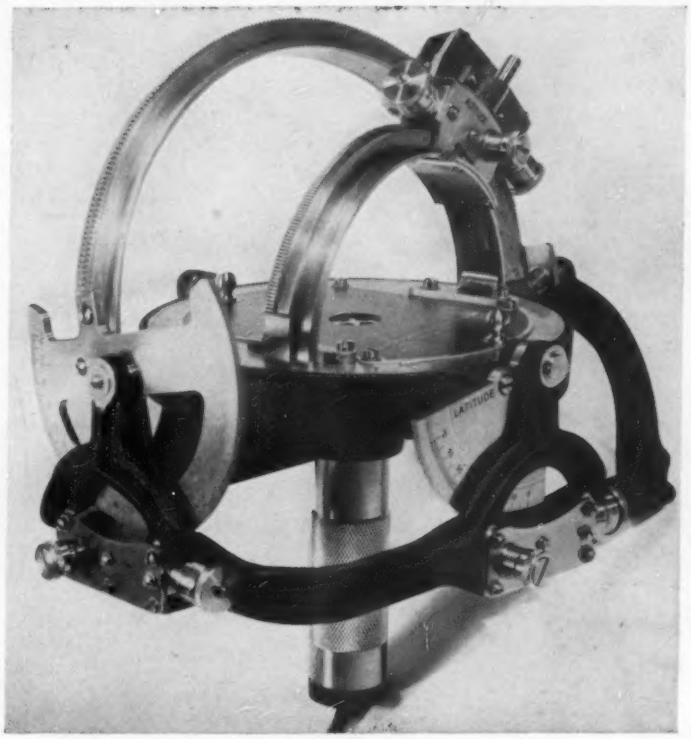
University training is also being belittled by the business men. They are blind to the need for constant study and investigation as a means of acquiring practical and worthwhile ends. These utilitarians would create a distrust and contempt for college training in general.

But with all these obstacles to freedom of education around them, the institutions must not allow themselves to be regimented by the government, or, as it would really be, to be run by a group of strongly nationalistic politicians. And, as Open House is a step toward the freedom of education, so is the Harvard tercentenary.

(*Continued on page 125*)



ENGINEERING DIGEST



POSITION FINDER

A navigation instrument developed by one of the leading aerial camera concerns of the country; the Hagner Position Finder quickly and automatically solves the spherical triangle. With this instrument it is possible to secure a fix in less than two minutes. To use the instrument one needs only the Nautical Almanac and a clock giving Greenwich civil time.

Invented by F. C. Hagner, the finder is a small compact instrument which may be held in one hand during an observation, leaving the other hand free for adjustments, or it may be placed on a gimbal for operation. Considered a miniature celestial sphere, it consists principally of a horizon plane, declination, latitude, and altitude arcs, and hour angle circle. The horizon plane carries the altitude arc, azimuth circle, and a spherical level bubble.

In the center of the bubble mounting is an eighth-inch diameter circle which is the geometrical center of the instrument and corresponds to the observer's position on the earth making an observation of a celestial body. The graduated azimuth circle rotates inside of the horizon circle which, when the instrument is properly set, gives the azimuth of any heavenly body sighted.

The declination arc is graduated in degrees and pivoted at the North and South poles of the finder frame. Thus when the declination of the observed body is set on the circle the motion of the body across the heavens can be followed by rotating this arc. By reading the hour angle circle which indicates the angular position, the exact longitude can be determined.

—Aero Digest.

STRAIN DETECTOR

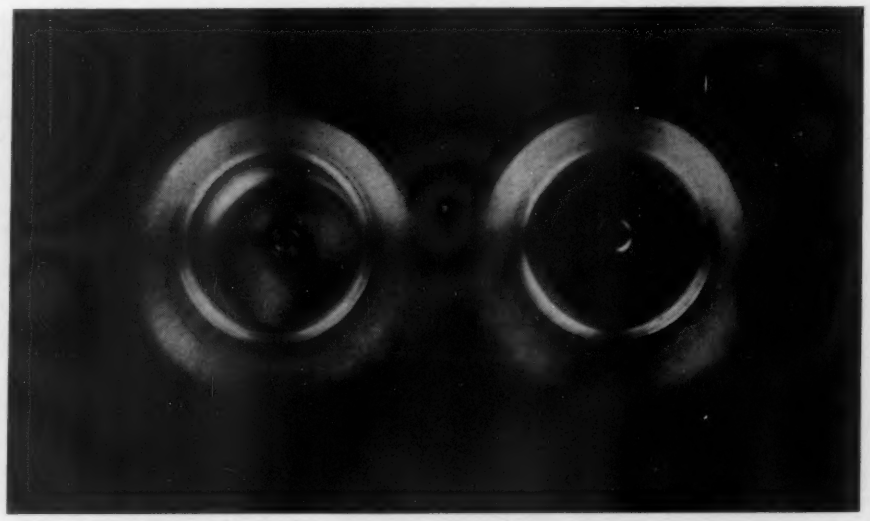
A new device that detects in glassware hidden strains, caused by faulty annealing, was demonstrated at the June meeting of the Society of Automotive Engineers. The detector makes use of Polaroid, a new light polarizing material.

Glassware that is free from strain appears uniformly dark when placed between two plates of the Polaroid detector, but when glass with internal strain is tested, the strain appears as streaks or blotches of bright light. Internal strains are caused by too rapid cooling or improper annealing during the manufacturing process. A jar, apparently perfect when it leaves the factory, may conceal a strain that cannot be discovered by ordinary inspection. This strain may end the life of the article abruptly and even dangerously when it is put into use.

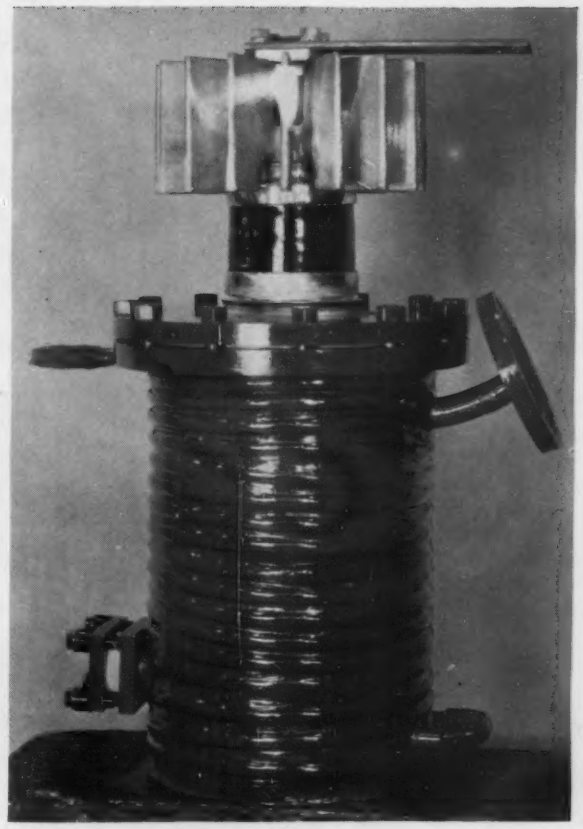
The new device may be used for the calculation as well as the detection of strains. It has been demonstrated with transparent plastics how structural parts such as beams, gear wheels, or shafts could be subjected in the tester to loads corresponding to those which the parts were to carry in service.

The detector operates on a principle well known to physicists, but because of the expense and inconvenience of obtaining polarized light, the principle never reached beyond the laboratory. The invention of Polaroid has converted the apparatus into a working tool for industry.

—Radio Engineering.



ARC BACKS



THE arc back has long caused rectification engineers countless trouble. The discovery of the principle of the igniter gives them control of the most obstreperous conditions favoring arc backs.

A rectifier consists essentially of two separated electrodes. Normally, with voltage applied between them, there exists near the surface of each a condition of reluctance to current flow. If at one electrode this reluctance is overcome, a cathode spot appears and current can flow at one polarity from that electrode to the other, but not at the reversed polarity.

Should a cathode spot form on the anode during the current-obstruction period, the current will flow in the reverse direction. This is an arc back and may be caused by dirt, insufficient vacuum, excessive mercury vapor density, or proximity of the two electrodes. The first three difficulties can be overcome by careful construction and operation of the rectifier. To overcome the fourth, the anode must be moved an undesirable distance from the cathode, or be surrounded by complicated grids.

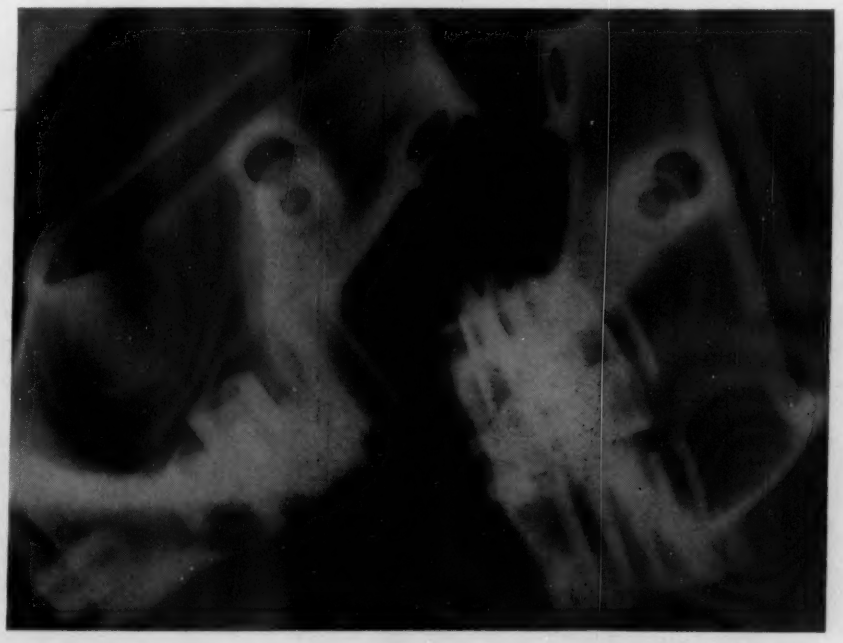
The cathode spot is not self-initiating, therefore if it is allowed to exist only during the current-flowing period, then no cathode spot could form on the anode, during the current-obstructing period. The igniter makes this thing possible. The igniter is a piece of high carbon resistance material, such as carborundum, dipping into the mercury. When voltage, of the proper polarity, is applied across it, a spark—the genesis of the cathode spot—occurs at the mercury surface to the igniter. Thus, a cathode spot is initiated only during the current-flowing period and prevents a back fire or arc back.

—The Electric Journal.

X-RAY INSPECTION OF METALS

ONE of the most promising methods for insuring that aircraft materials be sound and maintained by thorough checks during the life of the plane, is X-ray inspection which reveals the interior condition of structures and parts. Besides being adapted to appliance while the plane is under construction, it may be used periodically thereafter while the machine is in service. The X-ray evidence, in the form of negatives taken during construction and from periodical examinations of the craft, may be kept at the home port of the plane for comparison purposes and for the records.

European aircraft builders have been quicker to realize the potentialities of radiographic inspection than have the manufacturers here. Practically every aircraft factory abroad is equipped with X-ray apparatus. The main non-destructive test for metals that manufacturers of this country rely upon is magnetic analysis which is rather restricted in its scope.



Portable X-ray equipment, suited for inspection in the field as well as in the shop, is available today. The equipment includes a simple switchboard with control meters from which the apparatus can be operated. The X-ray tube is mounted in a ray-proof and shock-proof metal case with a small opening through which the useful ray escapes. Flexible shock-proof cables carry the high voltage from the power plant to the tube and the current required to generate the high voltage is supplied by the automobile engine of the unit. This makes the entire unit self-contained and independent of any outside power source. The peak-kilo-voltage supplied is sufficient to penetrate two inches of solid steel in one minute exposures at 24-inch focus to film distance.

—Aero Digest.

RESEARCH IN REVIEW

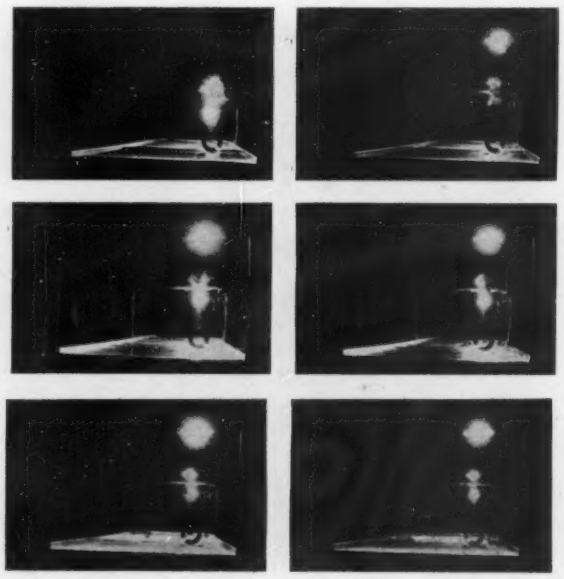
COURSE VI — Electrical Engineering

ILLUMINATING engineers of the Department of Electrical Engineering have completed an extended research program upon the problems of highway lighting. The program was instigated two years ago as a CWA-ERA project. In this project, known as the Massachusetts Highway Accident Survey, some 5000 field tests, taken under actual driving conditions, were made.

In order to fit the results of this project to a form more adaptable to practical use, a miniature highway was designed and built in the Illumination Laboratories. This model has proved its worth in studying the effect of lamp size, mounting height, type of pavement, and the relative importance of glare. It is operated in a room lighted only with the lamps of the model where an observer's "car", a vehicle much like a wheel chair, approaches the model at a definite speed. The distance between the model and the point at which the observer could first discern the gap in a "C" test object (International "C" object) was used to indicate different conditions of visibility. 15,000 tests made by seven observers have shown that a rough macadam requires about ten times as much light as does a concrete surface, whereas a smooth macadam requires three times as much light as the concrete.

These investigations suggested that a quantative analysis of highway vision might be obtained from the fundamental visual data, and the required visual-threshold data was experimentally determined in the Illumination Laboratories. For this data to be of use in the design of highway-lighting systems, however, it is necessary to have additional data which will enable the calculation of pavement brightness at all angles and with any type of street lamp. The most recent study, therefore, has been made to determine the reflection characteristics of a large number of street pavements. Photographs were taken of specimen pavements lighted by a single lamp of known intensity placed in a normal position. After the photograph had been taken, a test box, on which were several spots of known brightness, was placed on the roadway and a second photograph taken. The density of the negative referred to the brightness of the test spots could then be interpreted by a microphotometer. From the data obtained from these photographs curves for street brightness at any angle due to lamps of any candle-power distribution can be plotted.

It has thus become possible for the first time to calculate how a highway appears to a driver when it is illuminated by any lighting system, and how far away he will be when he sees an object. A highway-lighting system can now be evaluated and analysed in terms of its efficiency for seeing.



COURSE V — Chemistry

FINDING the cause and seeking the means for the prevention of the erosion or fitting of ships' propellers or of the blades of water turbines constitute important practical problems. Investigations by mechanical engineers have shown that this erosion is due to the phenomenon of cavitation, by which is meant the formation of small pockets of vapor whenever the water surrounding the blades is not able to follow exactly the rapidly moving metal. It is believed that the water rushes into these pockets striking the metal a sharp blow and gradually wearing it away.

The study of this problem, using actually operating machines, offers considerable practical difficulties. It turns out that certain technique employed by chemists in examining the effects of high frequency sonic (audible) and ultra sonic (inaudible) vibrations (sound waves), is suited admirably to the laboratory investigation of the problem of cavitation.

Recently in the Research Laboratory of Inorganic Chemistry, Professor Schumb, with co-workers, has been successful in adapting his magnetostriction oscillator to the study of this problem. This particular apparatus, designed originally to study the chemical effects of sound waves, is constructed of a hard-drawn nickel tube, twelve inches long and five-eighths of an inch in diameter, suspended vertically. It is made to vibrate longitudinally, by means of electrical devices, with a frequency of 8700 cycles a second, (the natural resonance frequency of the tube), and with an amplitude of vibration magnified several hundred times (actually about 0.06 mm. in absolute value). When one end of the tube is closed securely with a metal plug and dipped into a liquid the vibrational energy is transmitted to the liquid producing the physical effect of cavitation. Chemists using this apparatus have observed the formation of hydrogen peroxide in water containing dissolved oxygen and this chemical effect, and others have been claimed to be due entirely to cavitation. Be this contention as it may, the physical effect on the metal plug closing the tube is very pronounced. In a few minutes it is definitely eroded and the rate of wearing away of the metal can be determined readily. This observation is of great interest to engineers, and Professor H. Peters of the Department of Mechanical Engineering has joined in the research.

In order to test the susceptibility of many metals to erosion by cavitation, a threaded brass plug was soldered to one end of the nickel tube, permitting the attachment of caps made of any desired metal. By this means it has been found that the very hard and tough metals such as stainless steel resist this type of erosion most strongly while aluminum and its alloys have relatively little resistance. Bronze occupies an intermediate position. Soft metals like copper tend to flow in these erosion tests. Temperature has a marked effect, cavitation effects disappearing at the boiling-point of a given liquid. Dissolved salts often heighten the effect although some-

times only to a slight degree. Such a very hard (and brittle) substance as boron carbide was eroded when tested in this apparatus. Studies with this apparatus will be continued in the Research Laboratory of Inorganic Chemistry during the coming year with increased attention to the chemical effects which are admittedly less pronounced than the physical effects which have been described.

COURSE X — Chemical Engineering

THE researches of several doctors' theses completed recently cover a wide range of subjects.

R. C. Gunness has studied the performance of distillation equipment for the stabilization of gasoline. In this thesis have come various contributions to the art of designing large-scale rectifying equipment for multi-component mixtures.

The work of G. S. Bays on heat transfer in falling film condensers has brought out the advantages of this type of cooling apparatus in a number of cases where ordinary surface condensers are now used.

In his thesis, A. S. Parker has studied the mechanism of the combustion of solid carbon. His work shows the importance of oxygen diffusion to the surface in the combustion of powdered coal.

W. Ullrich has contributed many new data on radiation from gases, a factor whose importance in furnace design is now well recognized.

The polymerization of propylene has been successfully accomplished by L. A. Munroe. He has studied the products formed with reference to their possible use as anti-knocks in motor fuel.

J. P. Cogan has made valuable contributions to the knowledge of the bleeding of portland cement, a problem of great importance in the design of large concrete structures.

By correlation of the results of careful tests on steel reheating furnaces, J. E. Eberhardt has further developed the important technique of industrial furnace design.

The thesis of T. A. Gadwa has extended present day knowledge of the effect of such fundamental variables as vapor velocity and liquid composition on the efficiency of rectifying equipment.

The work of F. J. Jenney led to new understanding of phases of the industrially important problem of gas absorption by liquids with which the gas absorbed reacts chemically.

F. R. Russell has studied polymerization of ethylene dissolved in oil, clarifying some of the problems involved in the cracking of petroleum.

COURSE XII — Geology

LARGE scale geophysical explorations of the earth's crust and interior, and the commercial geophysical prospecting operations which have achieved such brilliant results in the discovery of oil, ores, and other economic minerals, are fundamentally very similar. The physical principles at the basis of each type of exploration are the same. It is true that the change in the scale of the operations sometimes entails modification of instrumental techniques, but the problems of interpreting the observational data are in general quite independent of the scale and remain essentially the same in both applications.

Undoubtedly the most productive single geophysical exploration method, whether in the field of pure or commercial geophysics, has been the seismic one. In this method the propagation of elastic waves in rocks, or of elastic surface waves over the ground, is studied. Changes in the type of rock at depth are revealed by changes in the velocity of the seismic waves, or by reflections and energy changes which may occur at concealed boundaries and transition zones. The appropriate

source for the lastic waves depends, of course, upon the geological scale of the problem. Thus, in the study of the deep earth as a whole, the source needs to be a world shaking earthquake, which may release as much energy as that represented by the fall of a cubic kilometer of rock from a 10 kilometer height near the base of the stratosphere to the earth's surface (about 10^{24} ergs); for studying crustal rocks and crustal layering down to depths of tens of miles large quarry blasts involving around 50 tons of dynamite are best. For small scale or shallow operations, such as delineating oil structures or determining depth to bed-rock in civil engineering, a source charge as small as one pound of dynamite or less may be used.

The seismometer in the illustration is one of a number which are being constructed for use as portable instruments in studying crustal rocks at depth, using as sources large quarry explosions. The waves from such explosions are observable within a radius of several hundred miles of the shock. This type of seismometer is also suitable and amply sensitive for observatory use in recording distant earthquakes, but is not sufficiently small and light for economical use in small scale prospecting operations, where maximum speed and portability are needed. The instrument records the vertical and the two horizontal components of the ground motion, as well as minute tilting of the surface, such as is produced by the tidal response of the earth to the moon's attraction. The small electrical coils seen are used to supply a known electromagnetic impulse to the seismometer pendulums. In this way the dynamic response characteristics and the magnification of the instrument may be conveniently ascertained. By means of a mechanical magnification element and an optical lever of length one meter, displacements of the pendulum centers are magnified as much as twenty-five thosand fold. Experience at the seismic observatories shows that magnifications appreciably greater than this value are seldom useful, because of the interference due to the slight background of groundvibrations, called microseisms, which are nearly always present.

COURSE VIII — Physics

IN the development at Round Hill, the most immediate problem is the construction of an evacuated, accelerating tube to be used in nuclear bombardment. The porcelain-steel tube, designed for horizontal mounting, is suspended between

(*Continued on page 122*)

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RESEARCH IN REVIEW

(*Continued from page 121*)

the terminals of the high-voltage generator, which provides the necessary acceleration for the electrified particles within the tube to impinge on the target and to cause the target to disintegrate or become radioactive. Although this method has advantages in simplicity and flexibility, several technical problems are involved. In connection with the design of the tube, it has been necessary to solve problems in the design of an ion source, high speed pumps, and associated vacuum equipment.

The generator being used in the development of this tube is a very large belt electrostatic generator and is now in regular operation at Round Hill. This type of generator consists essentially of an insulated terminal into which charge is converged by an insulating belt. In a recent publication, L. C. Van Atta, D. L. Northup, C. M. Van Atta, and R. J. Van de Graaff describe their experiences in the design and operation of the Round Hill generator where they have worked out on a large scale those problems peculiar to the belt electrostatic machine.

(*Continued on page 124*)

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Thermodynamics
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RESEARCH IN REVIEW

(*Continued from page 122*)

In the beginning there were the practical problems of operating wide paper belts, of eliminating vibration, and of controlling humidity. Then the design of the mechanism for depositing electrical charge on the belts required considerable attention, since it is necessary to have a very steady and sensitive control of the current delivered to the terminal of the generator. An improved design of generating voltmeter, together with a tested measuring technique, makes possible accurate and reliable voltage determinations. Complete performance data on the two units of the Round Hill generator indicate that the maximum values of total current, voltage, and power are 2.0 milliamperes, 5.1 megavolts, and 6.3 kilowatts.

Many of the problems at Round Hill have been especially serious because of the dimensions of the apparatus and the magnitude of the voltage involved. The present need for higher voltages in nuclear research, however, justifies the difficulties involved in such a machine.

During the past summer the Department of Physics has featured a special program in applied physics which included two conferences, one on spectroscopy and the other on color. At these conferences, held July 20–July 25, the color conference following immediately upon the closure of the conference on spectroscopy, papers were presented and discussed on many of the problems existing in these two closely-related fields. Members of the staff of the Institute delivered three of these papers at the conferences.

Mr. Richardson, a Research Fellow, contributed a paper in which he described analysis of spectrograms made with a spectrum plate which is driven at a definite rate of speed throughout the exposure. This makes it possible to determine what is occurring at any instant during the exposure. The analysis of spectrograms made with a moving plate is done by studying the variation in density of the spectrum lines along their length. This process enables the detection of even the smallest traces of all kinds of atoms present in a sample.

(*Continued on page 125*)

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EDITORIALS

(*Continued from page 117*)

For the Tercentenary served both as a challenge to the Unbelievers and as a rally call to the friends of free and liberal education. The exhibition of such a powerful 8000 man university was a convincing weapon against the ignorant cynics of the system of higher education. The discussions at the twelve day conference of the world's most brilliant minds were an excellent example of the progressive and vital problems which are dealt with effectively in colleges. The character of the men and the knowledge exhibited in the contributions were a joy and a satisfaction to all sound thinking people. Higher education had proved its mettle.

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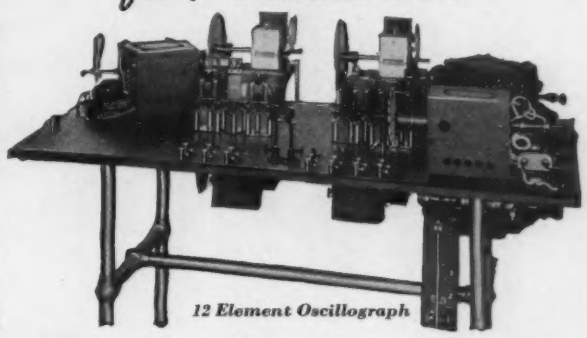

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RESEARCH IN REVIEW

(*Continued from page 124*)

By the ordinary spectroscopic methods it is not possible to determine all of the trace elements in a given sample, since the more volatile elements enter the arc only during the first few seconds while the elements which are slowest to enter the arc are not recorded at all. The moving plate method, however, overcomes this difficulty, and has been able, for instance, to identify the negative radical associated with a given metal in a chemical compound, a determination which cannot be made by the usual methods of emission spectroscopic analysis

At the color conference, Professor Frederick H. Norton presented a paper under the title of "Color Formation in Ceramics." This paper first discussed the color of raw ceramic materials, particularly clays which are used for paper filters, and dealt with some of the methods of treatment of these materials. Next, there was discussed the color produced in fired earthenware or porcelain bodies by various conditions, and the effect of various impurities in the clays was brought out clearly by the color curves. The mechanics of color formation in glazes was brought out by discussion of an exhibit of glazed tile. In conclusion, some color curves of glasses were shown and it was brought out that they gave much sharper bands than the glazes.

Mr. MacAdam, a Teaching Fellow in the Department of Physics, presented to the color conference a paper entitled "The Specifications of Whitness" in which he outlined the method which makes possible an accurate and truthful use of the popular terms white and whiteness. The grayness of a large group of samples was first determined, using the color analyser which was developed in the Color Measurements Laboratory. These samples were then given to a large group of people having ordinary color vision and each person arranged the samples according to his idea of increasing whiteness. The average order was then taken and compared with the measured grayness and yellowness of the samples. From the correlation of the results of these two procedures, a method was discovered by which the whiteness of any sample can be predicted by simply measuring in an optical instrument the grayness and the amount of color of the surface of the material.

CRIME DETECTION

(*Continued from page 108*)

The truly astonishing growth of radio and various teletype devices as a means of communication between law enforcement units is a far better indication of the value of this application of physics to scientific crime detection than any other proof which might be brought forward. Many cities and states are already equipped with radio systems which are capable of laying down at a moment's notice a comprehensive net through which the criminal has little or no chance of escape, and many others are considering the installation of such equipment. As yet, these units are more or less isolated with only occasional tie-ups between two or more systems; the maximum benefit, however, from this branch of physics will be realized only when coverage has been coordinated and made complete throughout the country, a goal worthy of the most serious consideration and effort.

While by no means complete as to the endless variety of cases in which the application of physical principles has proved of value, it is hoped that the brief discussion of the applications outlined above will serve to give some indication of the fundamental part played by physics in the rapidly developing field of scientific crime detection.

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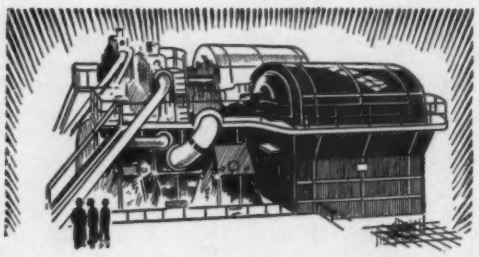
While '17 waited, '37 talks

WHEN the class of 1917 was at college, a long distance telephone call took (on the average) more than ten minutes to be put through. ¶ This time has been whittled down gradually, so that now the connection is made in an average of 1.4 minutes—nine out of ten of them while you hold the line. ¶ But this is only one phase of the relentless effort to improve. Your service is better today because voice transmission is clearer—interruptions and errors less frequent than ever before. ¶ America demands fast but sure telephone service—and gets it.

College men and women find after 7 P. M. a convenient time for long distance calling. Moreover, most rates are lowest then.

BELL TELEPHONE SYSTEM

G-E *Campus News*



BIGGER AND BETTER TURBINES

The new 110,000-kilowatt turbine-generator, built by General Electric and recently placed in service in the River Rouge plant of the Ford Motor Company, sets several new records in turbine construction.

It is the first large unit in the world to operate at 1200 pounds pressure and at 900 Fahrenheit. Although the weight is approximately 2,000,000 pounds, it is so compact that it occupies less than a cubic foot for each kilowatt of output. Because of its extremely high efficiency, less than a pound of coal is needed to generate a kilowatt-hour of electric energy.

The new turbine is a vertical compound machine with the high-pressure turbine and generator mounted directly above the low-pressure unit. Superheated steam enters the upper unit at 12 pounds and 900 degrees. After producing 55,000 kilowatts, the steam flows directly into the low-pressure unit where it produces another 55,000 kilowatts before it is exhausted to the condenser. This is the first 1200-pound turbine in which the steam enters the low-pressure stage without reheating.

The work of designing, constructing, testing, and installing great turbines, such as this, is the accomplishment of hundreds of graduates of technical colleges and universities—men who are also graduates of the G-E Test.

ELECTRIC HEAT FOR SOILLESS GARDENS

California nurserymen are growing tomatoes, strawberries, and sweet peas in chemically treated water heated by electricity. The method, developed by Dr. W. F. Gericke, of the University of California, has been extended to commercial installations. Tomato plants, grown in this way, produced unusually high-quality tomatoes. The yield was large, and they matured ahead of tomatoes grown in soil.

Nourishment for the plants is provided by special chemicals dissolved in the water. Because the water temperature must be accurately maintained, a controllable heat source is required, and General Electric engineers have supplied heating cable and thermostats both for the experimental installation and for commercial installations which have followed.

COFFIN FELLOWSHIPS

This fall eight young men will be carrying on advanced research in seven American universities under fellowship grants from the Charles A. Coffin Foundation. The recipients and their research problems:

George E. Boyd, U. of Chicago '33. At Chicago. Study of surface energies.

Lyman R. Fink, U. of California '33. At California. Phenomena in synchronous machines. Second grant of fellowship.

Alvin H. Howell, U. of Kansas '29. At M.I.T. Insulation problems in d-c transmission.

Russell A. Nielsen, Stanford '33. At Stanford. Electron mobilities.

Richard W. Porter, U. of Kansas '34. At Yale. Transients in the monocyclic network. Second grant.

Julian S. Schwinger, Columbia '36. At Columbia. Theoretical investigations in nuclear physics.

Chauncey Starr, R.P.I. '32. At Harvard. The pressure coefficient of thermal conductivity. Second grant.

Harold G. Vogt, U. of Buffalo '31. At Harvard. The nature of the neutron.

Since 1922, when the General Electric Company established the Charles A. Coffin Foundation in honor of the Company's first president, 113 fellowships have been awarded for advanced work in electricity, physics, and physical chemistry.

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